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Interactive comment on "Quantifying the Jakobshavn Effect: Jakobshavn Isbrae, Greenland, compared to Byrd Glacier, Antarctica" *by* T. Hughes et al.

Anonymous Referee #1

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General comments:

The authors present an unconventional geometric treatment of the force balance of ice sheets, streams, and shelves, and then apply their method to analyze the effects of ice-bed (un)coupling and ice shelf (un)buttressing on Jakobshavn Isbrae and Byrd Glacier. I generally appreciate creative theoretical approaches and simplified models aimed at physical understanding. However, I do think that the present manuscript requires a fair amount of clarification of both methods and results in order to fully achieve its goals.

My main concern regarding the methods centers around Figure 5 (which is too cramped to be easily readable) and the relative lack of explanation of the geometric

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approach. While the resulting equations are explored in depth, there is no clear example of how a geometric force balance is supposed to work. (Perhaps a simpler case, like an unbuttressed ice front, would be helpful.) The methods thus lean rather heavily (too heavily, in my opinion) on readers having access to earlier works by Hughes. Given that the geometric approach is quite unconventional, a clear explanation at the beginning is essential for readers used to "standard" continuum mechanics. Also, the exposition meanders a bit, so more signposts letting the reader know what is about to be derived and why would be quite useful.

My main concern regarding the presentation of results is that the discussion remains largely in terms of the parameters associated with the geometric approach. The results would likely be of greater interest to the "conventional" modeling community if they could be related to parameters used by ice sheet models (e.g., basal friction coefficients) or to outputs from such models (e.g., flux across grounding line). While the authors have managed to develop an alternative understanding of ice dynamics, it's just not clear to me as an ice sheet modeler how their insights should affect my work. Given that it's not too difficult these days to run a 1D flowline model, what can the geometric approach give me that I can't get from continuum mechanics? I'd be very interested to read a revised version that was more clear on this point.

Specific comments:

page 2044, line 20) "This is unlikely for the Antarctic and Greenland ice sheets", as written, appears to ignore the vulnerability of the Amundsen Sea Embayment that is deservedly associated with Hughes.

2046, 26) ISSM has the capability to do shelfy-stream and full Stokes dynamics also, so it shouldn't be classified exclusively as a higher-order Blatter-Pattyn model.

2048, 14) How did you determine these values of f were associated with particular flow characteristics?

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2048, 26) While you do have close-up maps of Byrd Glacier in later figures, it would be good to label it in Figure 1.

2049, 6) Is flow in the negative x direction then?

2049, 11) If tau_0 varies along x, and Eq (2) is obtained by differentiating Eq (1), there should be a d(tau_0)/dx term.

2050, 16) The sentence beginning "These velocities are used. . .." is somewhat confusing regarding which variables are considered to be known and which are solved for. This happens several other places as well, particularly when discussing solving for ice thickness/surface elevation, which I think are observed.

2051, 9 and following) The reasoning behind the yield criteria could be more fully explained, either here or in the Figure 2 caption.

2053, 22) "Since A is kept constant, the reduction of A" is a contradiction.

2054, Eq 8) Where did this equation come from?

2056, 17) Please clarify how you're using the terms "tension" and "compression" here for those of us who are used to thinking in continuum mechanics, divergence-of-the-stress-tensor terms.

2058, 1) Figure 5 is much too small to effectively illustrate what you're discussing. Could it be broken into multiple figures?

2060, 1) I can't follow your intuition in this paragraph. Is there any way to clarify graphically or mathematically?

2061, 12 and 20) What do you mean by "putting. . .between delta x steps"?

2062, 25) Is it reasonable in this situation to use an expression for tau_0 based on the shallow ice approximation?

2067, 14) Many of the concepts in Gagliardini et al (2010) originated with Walker et al

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(2008, GRL), which should also be cited.

2071, 4) Since you've already defined a buttressing parameter f_B, why isn't the unbuttressing parameter 1 - f_B?

2072, 1) I think you mean "unbuttressing" here.

2073, 15) How is phi_0 a "floating fraction"? I see that the form is similar, but not how this is interpreted as floating.

2075, 5) This definition of the Jakobshavn Effect as a product implies that the Zwally or Thomas Effect acting alone would do nothing, which doesn't seem right. Also, are you sure that Zwally and Thomas should be weighted equally?

2076, 21) "In recent years, subglacial lakes were found. . .." should have some citations, probably of Ben Smith and/or Helen Fricker.

2089, 15) I'm concerned that the equations don't always have solutions in the proper range. Are there particular approximations that went into them that you think may lead to this?

Technical comments:

2049, Eq 2) Because this journal uses a typeface that makes capital i look like lowercase L, you may want to use lowercase i as the subscript for "ice" and then use j or k as your iteration index.

2053, Eq 8) Due perhaps to Paterson's book, in the literature I have almost always seen A in Glen's law used as a prefactor, so that it's an ice softness parameter. I've most often seen the ice hardness parameter called B. I'm concerned that this may cause confusion for some readers.

2056, 26) I'm not sure that the right arrow, which is usually read as a limit, is the right notation for what you mean here for the thawed bed and confined shelf cases. I think the LaTeX symbols \lesssim and \gtrsim (combination of greater/less than and

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approximately equal) might be closer to what you mean.

Interactive comment on The Cryosphere Discuss., 8, 2043, 2014.